INFRARED ASTRONOMY WITH ARRAYS: The Next Generation

TITLE: Large Doping-spike PtSi LWIR Focal Plane Arrays for Astronomy*

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Si-based infrared arrays offer important advantages such as good uniformity, low I/f noise, and excellent reliability. Previously, 256 x 256 and 1024 x 1024 PtSi focal plane arrays have been used for ground-based astronomy in the short to medium wavelength infrared (SWIR and MWIR) regions. The modest quantum efficiency of the PtSi compared to InSb and HgCdTe detectors is more than compensated for by the larger format and long integration time allowed by the low I/f noise.

The performance of the PtSi arrays can be significantly improved by reducing the effective potential barrier and thus extending the cutoff wavelength. For example, by extending the PtSi cutoff wavelength to the LWIR region, not only can the quantum efficiency be increased by orders of magnitude in the MWIR region, but also can useful LWIR response be obtained.

In this paper, we present the doping-spike PtSi detector which offers tailorable LWIR response (> 22 μm) and allows system optimization and trade-off of the cooling requirements and the spectral response. Furthermore, it is compatible with the large-format focal plane array fabrication for high resolution imaging applications.

The doping-spike PtSi detector incorporates a 1-rim-thick p+ spike grown by molecular beam epitaxy (MBE) at the PtSi/Si interface. Due to the combined effects of an increased electric field near the PtSi/Si interface resulted from the doping-spike and the Schottky image force, the effective barrier height Eb is reduced, resulting in an extended cutoff wavelength which is given by $\lambda_c = 1.24/E_b$. Previous doping-spike approaches utilized relatively thicker doping spikes (> 5 nm) which formed a potential spike and thus required an extra tunneling for the photo-excited carrier collection, resulting in an significantly reduced responsivity and large tunneling dark current. The thin (1 nm thick) doping spikes incorporated in our detectors eliminated the potential spike formation, and consequently, the undesirable tunneling process. The thin doping spike requires an atomically sharp doping profile and a degenerate doping concentration ($>10^{20}$ cm^{-3}) and were grown by low-temperature MBE. Figure 1 shows the photoresponse of a typical 14 pm-cutoff doping-spike PtSi detector and that of the conventional PtSi detector. More than one order of magnitude improvement of quantum efficiency was obtain in the MWIR region, and useful photoresponse in the LWIR region was also demonstrated. By increasing the doping concentration of the p^+ spike, the cutoff wavelength can be further extended. Doping-spike PtSi detectors with a 22 μm cutoff wavelength have been successfully demonstrated.

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